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## **SOUR MILK: THE BEGINNING OF SCIENTIFIC MICROBIOLOGY**

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Here I shall not try to describe or even list the large numbers of experiments that Pasteur devised and carried out, to prove that in his words “fermentation is a phenomenon correlative of life.” Rather I shall select one instance because in his view and rightfully, I believe, it dealt with a situation crucial to the whole argument. This particular case is that of the conversion of sugar into lactic acid. This conversion occurs frequently in nature, for example, in the souring of milk, which most commonly results from the transformation of milk sugar into lactic acid. From the biochemical point of view, nothing could be simpler than this change, since it corresponds to the breakdown of one molecule of glucose into two molecules of lactic acid.

Because of its apparently simple chemical character, Pasteur selected this reaction as a test to demonstrate the role of living things in chemical changes. This move illustrates, I believe, the extraordinary sense of scientific showmanship that he displayed so often in life. What Pasteur showed in this study—as he did even more convincingly with other more complex fermentations—was that the lactic-acid ferment consists of an immense number of microscopic organized bodies, which all resemble one another. Moreover, he demonstrated that these formed bodies could be made to increase in number if he supplied them with the proper kind of food. Once grown in the pure state and in sufficient amount, the lactic ferment could be transferred to a new sugar solution, and then it accomplished with

extraordinary speed the transformation of the sugar into lactic acid.

By applying the same experimental approach to other types of fermentation, Pasteur showed furthermore that the acidity, neutrality, or alkalinity of the fermenting solutions had very profound effects on the activity of the various kinds of ferments. Thus, yeast produces alcohol most rapidly in an acid solution, whereas the lactic acid ferment is most active at neutrality. He even recognized—for the first time—the activity of certain antiseptics. Onion juice, he found, inhibited the action of yeast, but not of the lactic acid ferment. The ideas of a specific ferment associated with each fermentation, of disproportion between the weight of the ferment produced and the weight of matter transformed, of vital competition between two organisms simultaneously invading the same medium, resulting in the dominance of the one better adapted to the culture conditions—all these ideas, which the future was to prove valid and develop into a body of science and technology, are forcefully set forth in a short paper that he published in 1857 under the title, *Mémoire sur la fermentation appelée lactique* (Report on the lactic acid fermentation). This paper can truly be regarded as the beginning of scientific microbiology, indeed as one of the most important landmarks of biochemical and biological sciences. Its fundamental spirit can be summarized in Pasteur’s own words: “The purity of a ferment, its homogeneity, its free unrestrained development from foodstuffs well adapted to its individual nature, these are some of the conditions which are essential for good fermentation.”